Decreasing Time to Antibiotics in Febrile Patients With Central Lines in the Emergency Department

Meghan Jobson, PhD; Moses Sandrof, MS; Timothy Valeriote, RN; Abigail Lees Liberty, BS; Christine Walsh-Kelly, MD; Cheryl Jackson, MD

abstract

BACKGROUND AND OBJECTIVE: Rapid antibiotic administration is essential for the successful management of patients who have central lines and present with fever. We conducted an emergency department (ED) improvement initiative to deliver antibiotics to 90% of patients within 60 minutes and to minimize process variation.

METHODS: Our setting was an academic ED. We assembled a multidisciplinary team, identified contributing factors to the care delivery problem, determined key drivers and intervention steps, implemented changes, and used strategies to engage ED staff and promote sustainability. Outcomes were analyzed by using a time series design with baseline data and continuous postintervention monitoring. Outcomes included percentage of patients receiving antibiotics within 60 minutes, time to antibiotic administration, and accuracy for triage acuity and chief complaint.

RESULTS: An 8-month baseline period revealed that 63% of patients received antibiotics within 60 minutes of arrival, with a mean time to antibiotics of 65 minutes. Multiple Plan-Do-Study-Act (PDSA) cycles were used to improve patient identification and initial management processes. The percentage of patients receiving antibiotics within 60 minutes of arrival was increased to 99% (297 of 301), and mean time to administration decreased to 30 minutes (95% confidence interval: 28–32). These gains were sustained for 24 months. Subanalysis identified a racial discrepancy, with African American patients experiencing significantly longer delays than patients of other races (95 vs 61 minutes; \( P < .05 \)); this discrepancy was eliminated with our initiative.

CONCLUSIONS: Our initiative exceeded our goal of 90% antibiotic delivery within 60 minutes for a sustained period of at least 24 months, decreased process variation and mean time to antibiotic administration, and eliminated race-based discrepancies in care.

Central venous access devices place patients at risk for bacterial entry into the bloodstream, facilitate systemic spread, and contribute to the development of sepsis. Rapid recognition and antibiotic intervention in these patients, when febrile, are critical. Delays in time to antibiotic (TTA) delivery have been correlated with poor outcomes in febrile neutropenic patients. TTA was identified as a measure of quality of care in pediatric oncology centers, and a survey reported that most centers used a benchmark of <60 minutes after arrival, with >75% of pediatric cancer clinics having a mean TTA of <60 minutes. The same study, however, noted that more than half of the emergency departments (EDs)
examined had a mean TTA >60 minutes for these patients. Timely delivery of antibiotics in the ED can be a challenge. A retrospective study from 2004 reported a mean of 170 minutes from triage to antibiotic delivery in this population.4

Recent studies have described interventions to decrease TTA in febrile pediatric patients.5 However, to the best of our knowledge, no study has addressed sustainability, which is one of the most significant challenges for quality improvement efforts. One goal of these efforts is to determine whether, after cessation of the active intervention, the effect has been stably sustained.

The University of North Carolina (UNC) Hospitals ED provides care for ~65,000 patients annually, including 14,000 pediatric patients aged <19 years. Acute management of ambulatory patients who have central lines and fever often occurs in the ED. Ongoing management of pediatric patients with central lines is provided by multiple pediatric specialists, including oncologists, gastroenterologists, and hematologists. ED management of these patients, when febrile, varies significantly, making it challenging to provide efficient, effective, and standardized ED care. In addition to the challenges presented by this variation in care, several UNC Hospitals ED staff believed that febrile pediatric patients with central lines experienced unacceptable delays before receiving antibiotics. To validate this perception, a system to identify and review ED patient encounters was developed and tested. Examination of a 10-month sample revealed that only 63% of patients received antibiotics within 60 minutes of arrival, and the mean TTA was 65 minutes (range: 6–358 minutes). Seeing an opportunity to reduce the TTA and minimize variability, an improvement team was formed comprising frontline nursing staff, volunteer research assistants, and attending physicians.

We designed an ED initiative to address our key care delivery problem (ie, delayed antibiotic administration) in our target population: children with central lines presenting with fever as the chief complaint, regardless of underlying condition. The primary aim of the initiative was to achieve 90% of patients receiving antibiotics within 60 minutes of ED arrival; our secondary goal was to reduce mean TTA to <60 minutes and narrow the variation. We organized our initiative to actively engage caregiving staff in a structured approach to develop a consistent and sustainable process to expedite antibiotic delivery. Specifically, we planned to identify a benchmark and characterize and resolve any factors that were associated with delayed antibiotic administration.

**METHODS**

**Setting**

UNC Hospitals is a large, suburban, academic medical center that serves the southeastern region of the United States and all 100 counties in North Carolina. Tertiary pediatric care, including pediatric and neonatal level IV intensive care, level I trauma care, and emergency care, are provided. Pediatric emergency medicine physicians provide care in the pediatric ED between 8:00 AM and 2:00 AM. During the remaining hours, board-certified emergency medicine physicians in the general ED care for pediatric cases.

**Planning the Intervention**

A multidisciplinary improvement team was formed. We analyzed the results of the 8-month baseline analysis of current performance, reviewed the oncology literature and reports from other hospitals, obtained expert opinion to determine a benchmark for TTA, and established the initiative aims. The team consulted with other hospital staff involved in the care of pediatric patients with central lines and identified several additional operational factors that could be improved. The improvement team outlined the current process, identified key factors contributing to the delay in antibiotic administration, and suggested potential solutions to test using the PDSA model. Key areas for improvement included patient identification at triage, appropriate level of triage assigned, antibiotic availability, and a standard management process.

The initiative was conducted in 3 phases. Phase I focused on defining the problem, communicating the results of the baseline analysis and TTA benchmark to the ED staff, mapping the existing process, eliminating the step to contact the patient’s subspecialist before the initial treatment, and implementing solutions to address patient identification, triage acuity assignment, and access to antibiotics. Phase II focused on refining and embedding the patient identification and acuity assignment processes into standard practice through PDSA cycles, structured communication with staff, and transparency of performance data for key measures to enhance learning. Phase III used the key lessons learned and data collected from phases I and II to further redesign a standard patient identification and initial management process and to develop a guideline for the updated process. Finally, during the sustainability phase, active intervention ceased, outcomes were monitored, and communication with ED staff continued.

The primary strategies used in the present initiative focused on staff engagement and learning from collected and analyzed data. Effective communication, awareness of staff performance (by using data collection, analysis, and result reporting in real-time), and timely individual feedback provided the framework to deploy these strategies.
We created a system in which supervisors monitored staff members’ performance and conducted individual staff coaching sessions to identify factors contributing to performance lapses and to invite suggestions for improvement.

**Planning the Study of the Intervention**

Key measures selected for this initiative included the primary outcome, proportion of patients receiving antibiotics within 60 minutes of ED arrival, and a secondary outcome (ie, mean TTA). Process measures were also included and defined: correct chief complaint recorded (fever/central line) and accurate triage acuity (2) assigned. Data for race, primary language, and age were collected to identify possible patient-level contributors to increased TTA. These patient characteristics were obtained by self-report at the time of ED registration.

**Analysis**

Outcomes of the initiative were studied by using a time series design with baseline data obtained from the preceding 8 months and continuous monitoring after cessation of active interventions. The primary outcome analyzed was the percentage of patients receiving antibiotics within 60 minutes of ED arrival. Accurate triage classification and chief complaint were monitored to assess adoption and adherence to these changes. A statistical process control chart was used to monitor improvement, with control limits set at 3 SDs and a shift of ≥8 points above or below the mean being indicative of special cause variation (equivalent to \( P < .01 \)).\(^6\) Significance was also measured by using a 2-sample \( t \) test, with \( P < .05 \) indicating significance. Characteristics were compared preintervention and postintervention by using a Student’s \( t \) test for ED shift, length of stay for admitted patients, race, gender, age, and primary language spoken. The institutional review board of UNC Hospitals approved this project.

**RESULTS**

**Outcomes**

Over the course of this initiative, 479 patient encounters that met criteria took place (Table 1). TTA delivery was tracked, and the percentage of patients receiving antibiotics within 60 minutes of arrival increased from 63% to 99% after 8 months, exceeding our goal of 90% (Fig 1). TTA was lowered from a monthly mean of 65 minutes to 30 minutes, and variation was significantly decreased (Fig 2). Control charts demonstrated that antibiotic administration was reliably <1 hour by phase III and has been sustained for 24 months since our initiative goal was first met in June 2011.

Key improvement areas and specific interventions for the initiative are listed in Table 2. During phase I, the existing processes for identifying and managing febrile patients with central lines were mapped and analyzed. Key interventions that were tested and implemented included revision of the greeter role to include identification and notification of the triage nurse, designation of chief complaint as “fever/central line,” re-education and re-emphasis of triage acuity as 2 for these patients, and routine stocking of the Pyxis machine (CareFusion Corporation, San Diego, CA) with required antibiotics. ED nurses and greeters were informed of the baseline performance results, the benchmark suggested in the literature and by local experts, the improvement initiative goals, and their new role expectations. Reminders printed on bright card stock were attached to the monitor of every computer workstation used to access the electronic health record. Phase I interventions alone had little effect on timeliness. However, retrospective data analysis of the phase I changes helped the team to identify areas in need of improvement.

In phase II, strategies focused on improving performance by providing data and other information for learning, using a monthly newsletter, public sharing of aggregate compliance data tracking, individual reports of personal performance, personal coaching of noncompliant staff, and rewards for compliance. The monthly newsletter included graphs displaying performance for timely antibiotic administration, accurate triage acuity designation, and appropriate chief complaint designation. The newsletter also provided information about the initiative, highlighted a staff member each month who successfully achieved the initiative outcomes, and offered solutions to emerging problems with the initiative (ie, how to administer drugs if the central line port is blocked). The ED supplied hospital dining gift cards as incentives for performance. Newsletters were posted throughout the ED, in break rooms, and in high traffic areas with high visibility, and they were designed to be visually appealing, brief, motivating, and fun to read.

An additional key strategy used was the active encouragement of staff to

| TABLE 1 Patient Demographic Characteristics (\( N = 479 \)), January 2010 to June 2013 |
|---------------------------------|------------------|
| Characteristic                  | Value            |
| Mean age                        | 6.6 y            |
| Gender                         | 54% male         |
| Race                           | 59% White, 23% Hispanic, 10% African American, 2% Asian, 1% Native American, 5% other |
| Preferred language             | 77% English, 23% Spanish |
| Managing specialty             | 75% oncology, 11% gastroenterology, 8% hematology, 6% other |
identify problematic issues and propose subsequent solutions. A key intervention implemented during phase II as the result of this engagement was to develop placards to address access and language barriers; these were placed at the greeter’s desk. These placards were written in English and Spanish and requested that patients and families inform the greeter if a central line was present.

In phase III, a management guideline with key decision elements was developed and implemented (Fig 3). A new patient identification and initial management process was designed based on the steps, weaknesses, and challenges identified in the existing process map developed in phase I. This process benefited from feedback from frontline ED staff and the results of multiple PDSA cycles during phases I and II. Key strategies included ongoing communication via the newsletter and engagement of patient life and nursing coordinators from oncology and inpatient units. Incentives were discontinued in this phase, and the newsletter was transitioned from monthly to quarterly.

In addition to developing and implementing the guideline, a patient instruction and identification card was developed (Fig 4). These wallet cards, printed on brightly colored card stock in English and Spanish, were given to parents. The cards provided specific instructions for what measures to take if their child developed a fever and advised parents to notify their specialist providers, who were educated to direct the patient to the ED and to notify the ED before arrival. In addition, the cards provided a bright identification signal to the ED parking attendants and greeter staff that promoted rapid identification upon the patient’s arrival. Cards were distributed during clinic visits, in the ED, and during hospitalizations.

During the sustainability phase, data continued to be collected and reported to monitor ongoing performance and detect any performance declines should they occur. The newsletter continued to report key results, but the reporting frequency was reduced first to every 3 months and then to every 6 months. Strategies used to ensure the sustainability of our improvements included monthly orientation of residents to the process; a staff champion who maintained awareness and enthusiasm in the clinical setting; routine reporting at clinical practice meetings; and a shift in workplace culture to encourage identification of

FIGURE 1
Rate of antibiotic delivery within 60 minutes of arrival. Value shown is the proportion of patients in a given month that received antibiotics within 60 minutes of arrival. Interventions: Phase I: greeter role, triage acuity, chief complaint, Pyxis stock maintenance. Phase II: newsletter, coaching, incentives, patient cards. Phase III: management guideline (MG). Yellow line indicates mean. Blue line indicates lower control limit.
barriers, recommendations for changes, and self-reporting of lapses. In addition, a nursing order set was developed to hardwire key elements of the management guideline into our new electronic health record being implemented in the hospital. The rollout of this system did not take place before the end of the study period; however, this change demonstrates our ongoing commitment to sustain our improved process.

Ongoing analysis of data collected during the initiative revealed that day shifts, when pediatric emergency physicians provide care, were the first to meet goals. Initially, TTA exceeding 60 minutes tended to occur after 7:00 PM and in the general ED versus the pediatric ED. Enhanced communication efforts directed toward both nursing and physician night shift staff resulted in a resolution of this discrepancy by phase III of the initiative.

For all staff involved in encounters with antibiotic administration delays, loop closure was ensured via both e-mail and an in-person consultation encounter. Emphasis was placed on motivating the staff and soliciting input on how to ensure compliance to encourage ownership and engagement. Accurate assignment of acuity correlated with timeliness of TTA in the preintervention period ($P = .04$, Pearson’s $r = 0.21$) (Fig 5). Although there was no correlation between timeliness of TTA and correct chief complaint assignment (“fever/central line”) before the intervention, there was a strong correlation during the sustainability phase ($P < .0001$, $R = 0.33$) (Fig 6).

Analysis of baseline data from 2010 revealed significantly longer delays in antibiotic delivery specifically in African-American patients (Fig 7). Although these patients comprised only 10% of our study population, the difference was striking and statistically significant ($P < .05$).

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**TABLE 2** Key Improvement Areas and Specific Interventions for the Initiative

<table>
<thead>
<tr>
<th>Key Improvement Area</th>
<th>Improvement Step</th>
<th>Improvement Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient identification at triage</td>
<td>1. Greater role clarified to identify potential patients</td>
<td>ED nurses, project team</td>
</tr>
<tr>
<td></td>
<td>2. Posted placards at triage</td>
<td>Hematology-oncology and inpatient staff</td>
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<tr>
<td></td>
<td>3. Wallet card for families</td>
<td></td>
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<tr>
<td>Triage acuity assignment</td>
<td>1. Re-educated nurses on correct triage acuity of 2</td>
<td>ED nurses</td>
</tr>
<tr>
<td></td>
<td>2. Nurse education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Compliance reports</td>
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<td></td>
<td>4. Monthly newsletter</td>
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<tr>
<td>Antibiotic availability</td>
<td>1. Pyxis stocked routinely with antibiotics</td>
<td>ED nurses</td>
</tr>
<tr>
<td>Standard process</td>
<td>1. Guideline developed</td>
<td>ED nurses, project team, volunteers</td>
</tr>
<tr>
<td></td>
<td>2. Patient identification cards</td>
<td></td>
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Although no specific interventions were implemented, the gap was eliminated when our timeliness goals were met. During the sustainability phase, TTA was similar between all racial groups. In the years before and after the intervention, no differences in TTA based on gender, diagnosis, or preferred language were identified.

**DISCUSSION**

Our pediatric ED staff identified TTA administration in febrile patients with central lines as an area for improvement. Over the course of our initiative, the proportion of patients receiving antibiotics within 60 minutes of ED arrival rose from 63% to 99% and the mean TTA was lowered from 65 to 30 minutes, a 51% decrease. In addition, race-based differences in TTA that existed before our initiative were eliminated. Numerous PDSA cycles were conducted and several changes implemented during the course of the initiative. Changes implemented during phases I and II did not immediately result in a significant reduction in TTA administration. Significant improvement was ultimately achieved and sustained with the redesign of our ED management process and implementation of our practice guideline.

Multiple studies in the past decade have revealed the need for systematic and rapid administration of antibiotics in pediatric patients with central lines. Typically, such patients are medically complex, and the development of sepsis can be a life-threatening event. Most cancer centers successfully use a benchmark maximum of 60 minutes to antibiotic delivery in febrile patients with a central line, and we adopted this benchmark as the primary initiative goal and outcome measure. Recently, a quality improvement initiative focused on introducing such a benchmark in a pediatric ED. The initiative achieved 88.5% of patients...
receiving antibiotics within 60 minutes. Although this initiative successfully lowered TTA, variable results arose with time during the 15 months after implementation, especially toward the end of the observation period. This project listed parents’ refusal of central line access and complications of analgesia placement as challenges to lowering TTA. Staff user fatigue was listed as a possible barrier to sustainability of the measure, possibly due to a lack of continuous feedback regarding outcomes.

The present initiative achieved and consistently sustained a goal of rapidly delivering antibiotics to febrile pediatric patients with central lines. We attribute much of the success of our efforts to both the involvement of an effective staff caregiver champion who encouraged a culture shift from complacent routine to active engagement and a deliberate plan to seek feedback from the front line to improve the process. Discussions of recently reported performance results were common during work hours, indicating a high level of staff member ownership of the initiative. Additional factors contributing to the success of the initiative were physical reminders of the initiative on computers and elsewhere throughout the department.

Elimination of racial and other disparities in health care is a key focus of many national agencies, including the Centers for Disease Control and Prevention, the Agency for Healthcare Research and Quality, and the Office of Minority Health, among many others. In the analysis of our preintervention data, we identified a racial disparity in TTA as African-American patients experienced greater delays in antibiotic administration. Similarly, a highly publicized study identified racial/ethnic disparities in ED pain management, finding that non-Hispanic black patients waited longer for pain medication than other groups. Although our initiative did not focus on identifying the reasons for our racial disparity and did not implement any specific interventions, we believe it is important document and report these disparities. It is also of interest to report the elimination of this disparity, which may have resulted from a number of factors, including staff awareness and implementation of a standard management process.

Our improvement initiative had one significant limitation. Although inclusion of a balancing measure is optimal for improvement initiatives, we were unable to identify an effective and meaningful balancing measure and did not measure impact on the care of other ED patients.

FIGURE 5
Although it is possible that focusing on our specific patient population resulted in compromised care for other patients, we believe this is unlikely due to the low volume of pediatric patients with central lines in the ED.

In EDs at teaching hospitals, consistent practice is often challenged by the regular monthly rotations of residents and other trainee staff. In anticipation of the potential negative impact of this rotating trainee issue on maintaining efficient antibiotic delivery, we specifically informed rotating residents of the initiative and management guideline during their ED orientation. By holding temporary staff accountable to the same standards as permanent staff, we cultivated a team atmosphere and strengthened the goals of the project.

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**FIGURE 6**

**FIGURE 7**
TTA according to race (A) before and (B) after the initiative.
CONCLUSIONS

We conducted an improvement initiative in the pediatric ED that consistently lowered TTA in febrile pediatric patients with a central line. This change was sustained in the 2 years after active intervention that we continued to monitor outcomes. In addition, we discovered and eliminated a race-based TTA discrepancy in African-American patients.

ACKNOWLEDGMENTS

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